SYNOPSIS for Ph. D.

1.	**Title of Dissertation** :	Development Of Needle Punched Nonwovens for Pervaporation Membrane
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Development Of Needle Punched Nonwovens for Pervaporation Membrane

Abstract of proposed work plan/ problem:

Pervaporation have been established over the past two decades as improved technology for dehydration of organic solvent like alcohols, esters, ethers, as well as separating various types of organic compounds mixture. Pervaporation is membrane based process for separating binary or multicomponent mixture of miscellaneous organic fluids. The separation of mixture of different component is affected by pervaporation membrane. These non-porous pervaporation membranes made of polymeric materials which are having different permeability towards different components resulting in separation of component. The membranes are formed by using different materials, different process in required conditions.

1. Introduction:

Pervaporation process is used in number of industries for several different processes like industry chemical purification, analysis and separation due to its simplicity in process and in- line nature. The membrane acts as a selective barrier between two phases. The separation of components like ethanol and water is based on a different transport rate of individual components through the membrane. This transport mechanism can be described using the solution diffusion ,dehydration, purification of component into membrane and its diffusivity through the membrane which will different for different component and that membrane type leading to separation pervaporation.

Basic principle of pervaporation process can divided into three steps:

- Absorption of permeating components at feed side into membrane.
- Transport of components across the membrane by diffusion.
- Desorption at the permeate side into vapour phase under vacuum.

Two values characterize a membrane:

- Its selectivity (separation characteristics).
- The permeate flux across the membrane (mass transfer rate)

The main advantages of pervaporation are-

1) Mixtures at normal distillation form Azeotrope are easily and economically separated.
2) Low energy consumption or pervaporation.
3) Due to modular design of membrane system even small units can operate economically.
4) It is simplest method.
5) High degree of flexibility regarding feed mixtures that may contains various feed mixture, multi-purpose systems in one unit.

2. Review of Literature and Development in the subject (Previous work done in the relevant area):

Ample of studies have been carried out related to different pervaporation membranes of ethanol and water and read them. The literature are about the different types of membrane used and their selectivity and permeate flux, properties of membrane, different process / methods used to separate the ethanol and water are highlighted in some papers.

Michael R. Ladisch *et.al*. [1] Studied "Dehydration of Ethanol: New Approach Gives Positive Energy Balance". The dehydration of ethanol in which combustion energy of ethanol is more. Drying of aqueous ethanol by cellulose, corn, starch, shelled corn, oxide, hydroxide sulfate .In this study, water was removed from aqueous ethanol by using cellulosic materials. Alcohols are mainly made from either from grains or biomass by converting fermented sugars. Then sugars fermented with yeast give 6-12 % ethanol

along with aldehyde, ketones, amyl alcohol, methanol, etc. in small quantity. Final stage is distillation to water free alcohol and methanol. The recovery of ethanol from the fermentation require three step process-a) distillation of dilute aqueous alcohol to its Azeotrope. b) Distillation using either organic Solvent or salt solution to break up Azeotrope and removing the water. c) Distillation to separate water from third component so, it can be recycled. Analysis of ethanol-water distillation using the McCabe- Thiele method to analyze the fraction columns which are indicates the energy sensitive regimes. Energy consumption increases with decreasing ethanol in concentration in feed below 4% alcohol so, larger quantity of feed vaporized is required to obtain same amount of product. This fermentation technology result into product containing 5%-12% ethanol. So, like this by using different dehydrating agents like NaOH,$CaSO_4$, sucrose, corn starch, corn residue are drying the ethanol so, dehydration of ethanol is done. Dehydration is carried out in required conditions and test the result how much ethanol % at starting and how much it dehydrate.

M. H. V. Mulder *et.al*. [2] Done experiment on "Ethanol Water Separation by Pervaporation". The separation of ethanol water mixture is important for production of ethanol from biomass .The type of membrane structure to be used as to be considered because the structure of membrane determine separation mechanism of ethanol and water mixture by evaporation. Pervaporation occurs according to solution mechanism transport taking place only by the diffusion and not by convective flow. This is dense homogeneous membranes without permanent pores necessary. Some types of membrane possible like homogeneous membrane, asymmetric membrane composite membrane. In symmetric homogeneous membranes thickness contributes to resistance to mass transfer and asymmetric, composite membranes resistance is situated in thin dense top layer. These three membranes we are used to separate ethanol and water. These three membranes prepared with required terms and conditions. Pervaporation is combination with ultrafiltration to remove ethanol preferentially and continuously from fermentation reactor. The ethanol and water Purified by two stage process with three membranes.

They did not succeed in preparing thin top layer by this technique without loss selectivity. A both homogeneous and asymmetric membrane prepared from polymer has high selectivity to ethanol water mixtures. Annealing of homogeneous cellulose ester membranes had a positive effect on selectivity.

M.H.V. Kumar *et.al*. [3] States about "The Mechanism of Separation of Ethanol/Water Mixtures by Pervaporation- Calculation of Concentration Profiles". They applied modified solution diffusion model for separation by Pervaporation of ethanol –water mixture through cellulose acetate. It describes the transport of liquid mixture through homogeneous membrane .The model takes into account coupling in thermodynamic part as well as in diffusive part of transport equations. Concentration profiles of water and ethanol in cellulose acetate membrane have been calculated by apparent concentration independent diffusion coefficient and diffusion coefficient with exponential concentration dependence. The transport of ethanol water mixture by Pervaporation cannot be described with a concentration independent diffusion coefficient.

W. Kujawski [4], in his research on "Application of Pervaporation and Vapor Permeation in Environmental Protection", reviewed about pervaporation and vapor permeation which includes membrane separation techniques used to separate liquid mixtures. In order to prevent or to minimize the disposal of effluents or to recycle by-products the liquid substances should be separated specifically from the mainstream.

In general Pervaporation and vapor permeation will specially be used in those cases where small quantity has to be removed from large quantity. Pervaporation and vapour permeation have been identified as areas of vast potential for future research and commercial development.

Xia Zhan, *et.al*. [5] Research work on "Pervaporation of Ethanol/Water Mixture with High Flux by Zeolite –Filled PDMS/PVDF Composite Membrane", found that the

Zeolite –filled PDMS (polydimethylsiloxane) / PVDF composite membranes were applied for the pervaporation of ethanol /water mixture and showed higher flux. Zeolite-filled silicone/PVDF composite membrane was made by incorporating the zeolite particles into PDMS membranes. This results in to the higher total flux of composite membrane than that of filled PDMS membranes. Increase zeolite filled loading (10%-30%) and Si/Al ratio (from 38-300) improved both the total flux and separation factor. The zeolite filled PDMS membrane with zeolite loading of 305 gave total flux 821g/m^2, and separation factor of 13.7 with 5% ethanol concentration at 50ºC. As temperature increased from 40º C to 80ºC, separation factor varied from 12.1to 13.7 and total flux increased from 435.5g/m^2h with 30% zeolite. The zeolite filled PDMS/PVDF composite membrane with 30% zeolite loading was ethanol perm-selective in wide range of ethanol feed concentration (5wt%-90wt %), specially showed very good pervaporation performance in low concentration. The excellent pervaporation performance obtained from this was quite stable and lasting for long time result.

Atilla Evcin *et.al*. [6] Worked on "Pervaporation Separation of Ethanol –Water Mixtures by Zeolite-Filled Polymeric Membranes". Pervaporation process has a great potential to separate the volatile Organic Compound (VOCs)/water mixture. By incorporation of zeolites into rubbery polymers which has been showing the increase in permeability and selectivity in Pervaporative separation of organic compounds from water. There Polydimethylsiloxane (PMDS) is used as an elastomer. Homogeneous PDMS membranes can be made by solution casting technique in which hydrophilic/hydrophobic zeolite into polymer matrix. This membrane tested on scale pervaporation experimental set up. Composition of zeolites on permeation flux and separation factors investigate with experimental parameters for ethanol and water mixtures at 50ºC using zeolite-filled, hydrophilic 3A and hydrophobic silicalite-1membrane.

After this it was concluded that –1.Increase of zeolite content (3A) in the membrane shows increase in the water and overflow fluxes, while decrease in separation factors and ethanol flux remains almost constant. 2. Increase in zeolite content (silicalite-1) in the

membrane increase ethanol and all fluxes while a decrease in the water flux. 3. Physicochemical characteristics, degree of hydrophobicity of zeolite strongly influences the pervaporation properties of membrane. 4. Hydrophobic zeolite provides higher selectivity and flux than hydrophilic zeolites, 3A.

Juan Camilo Diaz *et. al.* [7] had experiment on "Separation of Ethanol- Water Mixture Using Type –A Zeolite Molecular Sieve". This paper state that synthesis of type –A zeolite molecular sieve can also separate the ethanol –water mixture. By using reactive mixture source of alumina, a source of silica and promoter type-A zeolite molecular sieve is formed. Characterization of the molecular sieve obtained by using X-ray diffraction (XRD), absorption isotherms and scanning electron microscopy (SEM). It concludes that part of product presented a pore diameter suitable for the separation of ethanol-water. Also observed that with regard to the pressure, the selectivity diminishes while the flow of mixture increase slightly. The total flow increase as water separation of the mixture occurs.

T. Uragami *et. al.* [8**]** are worked on "Dehydration of an Azeotrope of Ethanol/Water by Sodium Carboxy methyl cellulose membranes Cross-Linked with Organic or Inorganic Cross Linker". The pervaporation is a promising technique for separation of Azeotrope like aqueous solution of 96.5 wt. % ethanol through polymer membrane. For this separation physical and chemical properties of membrane are important. The membrane is made by linking sodium Carboxymethylcellulose (CMCNa) membrane link with organic /inorganic cross link. To control swelling of CMCNa membrane, mixture of CMCNa is an organic component and glutaraldehyde (GA), Tetraethoxysilane (TEOS) are inorganic components. A mixture of CMCNa is prepared .CMCNa/GA cross linked and CMCNa/TEOS hybrid membranes are formed. These membranes used to investigate the effect of GA or TEOS content on the ethanol/water selectivity and permeability of membranes. Both membranes showed high selectivity.

Consequently, it was found that addition of cross linking structure into CMCNa molecule was effective. Selectivity of CMCNa/TEOS hybrid membranes was higher than CMCNa/GA membrane. TEOS homogeneously dispersed in membrane therefore suitable cross-linked structure formed. It give more cross linked points than GA. So, denser structure formed the swelling of membrane is controlled. The changes in properties of CMC membranes cross –linked with 10wt% of TEOS by sol-gel process has more hydroxyl groups and consequently chemical and physical structure is fine. In this study, these membranes with high water/ethanol selectivity designed by hybridization of CMCNa and TEOS using sol-gel reaction, CMCNa offers potential for selective separation of an Azeotrope of ethanol/water.

Joanna Marszalek *et.al*. [9] Did work on **"**Efficiency of acetone –Butanol –Ethanol-Water System Separation by Pervaporation". The focus was on pervaporation process used to separate a quaternary system acetone-butanol-ethanol-water which is used in internal combustion engines. Composition and temperature of feed/permeate pressure in pervaporation greatly affect the membrane separation performance. A higher concentration was observed for a lower share of butanol with the feed .ethanol, acetone to a low degree concentration. The permeance coefficient for butanol is reached to an average value of 7.06×10^{-3} in comparison with ethanol 3.24×10^{-2} and acetone 1.83×10^{-2} [kmol m2h)]. Temperature change from 50-70º C led to an increased permeance factor. There were no apparent effects of feed flow rate on efficiency in this process. Due to the hydrophobicity of the membrane water fluxes in the quaternary system were negative. Membrane operated by high temperature would have more efficiency of separation of acetone-ethanol-butanol-water system.

Emmanuel Godwin *et.al*. [10] In their experiment on "Pervaporative Separation of Ethanol-Water Mixture Using Composite Membranes with Hydrophilic Zeolite Filters Made from Ghanaian Clay Deposits", prepared three different zeolite clays from clay

deposits at Abonka, Anfoega and Teleku-Bkazu in Ghana at room temperature. PVA based composite membrane filled with zeolite made from Ghanaian clay. For ultra –thin PVA composite membrane the substrate used of polysulphone. These fillers are hydrophilic. Pervaporation cell was fabricated from scrap aluminum and feed concentrations from 60-90 volume % ethanol can be separated. Final concentrations after 10 hours produce relatively higher concentrations of ethanol.

Pervaporation Separation Index (PSI) increase generally with ethanol concentration in the feed and this ideal membrane with high PSI corresponding to high flux and high separation factor. Same trend observed in this membrane. Feed concentration of 87.5 wt%, the mixture was rich to 95 wt% concentration. In preliminary study states 75% higher separation factor with this clay filler probably due to its high Si: Al ratio.

Alexandra Yu Pulyalina *et.al*. [11] Worked on, "Ethanol purification from methanol via Pervaporation using polybenzoxazinoneimide membrane". Since the 1980s ethanol was applied in the energy market as a promising alternative energy source. In number of countries ethanol efficiently employs as automobile fuel. It can be used as independent fuel or additive. Now ethanol is produced by enzymatic fermentation. However the product of fermentation, except the mainadmixhren such as water and CO_2 contains methanol which can be derived from biomass. Material used:-Solvents and reagents were purified and monomers were synthesized. Membrane PBDI films (~20-30 um thick) was obtained by casting the 10 wt. % .and heating PI-PAA membranes as a result of the solid state reaction. The heating was carried out in step mode like 120°c for 30 min, 140°c for 20 min, 160°c for 20 min, 200°c for 20 min, 250°c for 30 min, 300 for 30 min in the electrical furnace in an organ atmosphere.

In Pervaporation of methanol/ethanol mixture over the concentration range from 5 to 20 wt% methanol in the feed, the polybenzoxazinoneimide (PBOI) membrane was preferably permeated by methanol with high separation factor. Total flux through the membrane is mainly determined by the menthol flux due to its high sorption and

diffusion parameters. Contribution of ethanol flux is very low. Study on driving forces normalized properties showed high perm selectivity of polybenzoxazinoneimide (PBOI) membrane in Pervaporation of methanol /ethanol mixture.

Xin Chin, *et. al.* [12**]** has worked on "Separation of Alcohol-Water Mixture by Pervaporation through a Novel Natural Polymer Blend Membrane-Chitosan/Silk Fibroin Blend Membrane". In this the selective solubility and pervaporation properties of alcohol and water were studied. The result showed that membrane was water selective and the separation Factor of ethanol-water mixture could be improve compare to pure chitosan membrane. When silk fibroin content in blend membrane was no more than 40 wt% membranes used or pervaporation of alcohol-water mixture are classified into two categories -water selective membrane alcohol selective membrane chitosan is one of the widely selective membranes.

Peter Kreis *et.al.* [13] Worked on "hybrid membrane-distillation process". Complex distillation steps and/or the use of an entrained are required to separate azeotrope mixtures into pure components. Industry applied processes are azeotrope, extractive and pressure-swing distillation. Another sophisticated process consists of distillation and membrane separation. Especially pervaporation (PV) and vapour permeation (VP) are very suitable for this application, because for membranes the separation is very selective and is not limited by the vapour-liquid equilibrium. Therefore hybrid membrane processes have attracted much attention in recent years.

Besides high selectivity and compact design, PV and VP facilitate the simple integration into existing processes. Volatile components are separated by a non-porous membrane due to different sorption and diffusion behavior. Consequently the separation is not limited by the vapour-liquid equilibrium which is the main advantage compared to common separation processes. The driving force is the gradient of the chemical potential which is generated by lowering the partial pressure of the most permeating component on

the permeate side. Usually this is achieved by applying vacuum. The main difference between PV and VP is that the feed in VP is supplied as vapour whereas in PV the feed components change their aggregate state from liquid to vapour while permeating through the membrane. In PV the energy required to vaporize permeate is provided by the liquid feed stream. Therefore the liquid stream exits the membrane module at a decreased temperature.

I. D. Gil, *et. al.* [14] had aim of "Separation of Ethanol and Water by Extractive Distillation with Salt and Solvent as Entrained: Process Simulation". Chemical industry uses anhydrous ethanol for production process of solvents, aerosol, medicine, detergent paints, compound chain, fuel, etc. So, to simulate and analyze an extractive distillation process for azeotrope of ethanol dehydration with ethylene glycol and calcium chloride mixture as entrained. This work developed using extractive distillation by salt and solvent. Calculation of activity coefficients are describes vapor liquid equilibrium of ethanol –water ethylene glycol –calcium chloride system done with NRTL-E thermodynamics model. This dehydration process uses two columns i.e. main extractive column and recovery column. The solvent which is feed the molar ratio S/F-0.3, molar reflux ratio RR-0.35, no. of theoretical stages Ns-18, feed stage Sf -12, feed solvent stages SS-3, feed solvent temp TS -80ºC determine required energy consumption is reduced and distillate with 99.5% mole ethanol. The simulation results supported on basis of thermodynamic model describe the mixture behavior.

The reflux ratio has more effect on energy consumption and operated at low values with 70-90º C.S/F ratios useful for changing the operating conditions of column and used to obtain high ethanol concentration in overhead product with less energy consumption. Due to molecular sieves consumption of energy is less but additional energy for redistill the alcohol recycle by operation. With this process ethylene glycol in final product is lower than minimal required and salt is not present. Therefore this method is suitable for separation of ethanol and water.

Leppäjärvi, Tiina [15] studied “Pervaporation of alcohol/water mixtures using ultra-thin zeolite membranes”. The author says that the production of liquid transportation fuels such as bioethanol and more recently also bio butanol from renewable resources has received considerable attention. In the production of bio-based alcohols, the separation steps are expensive as the mixtures to be separated are dilute. As an energy-efficient separation technology, Pervaporation is considered to be potential processing biofuel purification. In order to obtain high fluxes, the performance of ultra- thin zeolite membranes in pervaporation was investigated. Binary ethanol/water and n-butanol/ water mixtures were studied using both hydrophobic and hydrophilic zeolite membranes for alcohol concentration, as well as dehydration. Due to the low film thickness of the studied membranes, the fluxes were generally higher than reported earlier. Nevertheless, the evaluation in this work showed that the Pervaporation performance of the ultra-thin membranes decreased due to flux limitation by membrane support this thesis provides knowledge of using ultra-thin zeolite membranes in the Pervaporation of alcohol/water mixture sand offers tools for pervaporation modeling. From above it is concluded that the main constraint of hydrophobic membranes in e.g. ethanol/water pervaporation has been the low flux, although the achieved separation factors especially in the case of zeolite membranes are reasonably high. The flux through a membrane can be increased by decreasing the membrane thickness. In this work, ultra-thin (0.5–1μm) alumina-supported MFI and FAU zeolite membranes were studied in the pervaporation of5aqueous ethanol/n-butanol solutions. Based on the experimental results, it can be concluded that the membranes studied in this work have potential in the recovery of products in bioethanol and bio butanol production.

John H. Bermudez and *et. al.* [16**]** had done experiment on “Pervaporation: Promissory Method for the Bioethanol Separation of Fermentation”. Biomass is a promising alternative for energy and chemicals derived from petroleum and other fossil based fuels. Now days ethanol is used as source of energy form any countries like Brazil and US. Basically the ethanol is extracted from sugarcanes in Brazil and from corn in US.

Pervaporation is a process in which the component of interest , in liquid state is removed from matrix liquid(feed) through a membrane by the application of a differential pressure(low-pressure) between the walls there sufficient to bring the component into a gaseous state and get it removed on the other side of the membrane , obtaining a flow with a high concentration of the desired component(permeate) in gas state and another flow with low concentration of the desired component (permeate).This process can be operated by applying a pressure differential between the membrane walls through a vacuum pump or a carrier gas, thus obtaining a gaseous flow that is subsequently condensed into the permeate. For the pervaporation there are two models are used, pore Flow model and the solution-diffusion model. The simulations were carried out in the PERVAP Simulator developed and validated by Alvarez (2005).This software is based on the solution diffusion model to represent the mass transport of the permeate components through the Membrane. The free-volume parameters are calculated using viscosity data. The temperature of pure components, and the binary interaction parameter (component/polymer). The specific Critical hole-free volume was estimated by the additive method of atomic constant of "Sugden". It was observed that for the PDMS membrane and the set of conditions used in this research project for the recovery of ethanol, a higher permeate ethanol concentration is obtained even when the ethanol concentration is low in the feed , as shown by separation factor, Which could fit well with existing conditions in industrial plants.

Prof. Shakhashiri, [17], "Chemical of the week – Water". States that water covers about 70% of earth's surface makes up about 70% of your mass and essential for life. Water naturally exists on earth in three physical state of matter- gas, liquid, solid. Water is having more molar mass. So, boiling point is 100 ºC. The melting point is more than the value expected at its lower molar mass. Water has second highest surface tension in liquid after Mercury. Surface tension of water is 72.8 dynes cm^{-1}.The ionic solutes, singly charged anions and captions, Nalco, NH_4NO_3, etc. are soluble in water. Salts multiply charged contain sand anions, $BaSO_4$, $CaCO_3$, Co3 (PO_4) are insoluble. The acid –based

chemical properties of water helps in dissolution of solutes that also have acid-base properties. In some cases water act as acid with other molecule like ammonia then form acetic acid.

Enrico Drioli and *et. al.* [18] had done research on "Membrane Distillation". Membrane distillation is a membrane separation process. The membrane distillation means the separation of two mixed liquids in the vapor form. In this process high solute concentrations can be reached, overcoming concentration polarization phenomena and ultrapure water can be produced as permeate. For this process the special type of membrane is used called as micro porous hydrophobic membrane. This membranes are having very small porous on its surface and it is hydrophobic in nature so liquid cannot be passes through the membrane only liquid vapor allow to pass through the membrane. Micro porous hydrophobic membrane separates two aqueous solutions at different temperatures. The system consists of a porous hydrophobic membrane, separating two aqueous solutions of a non-volatile component maintained at different temperatures. Due to the liquid-rejecting properties of the membrane material, the liquid phase is prevented from penetrating the pores, as long as the pressure of liquid does not exceed the minimum entry pressure of the porous partition. Liquid-vapor interfaces are formed on both sides of the membrane pores and, due to the temperature difference; a vapor pressure difference is created between sides of each pore. Evaporation takes place at the warm interface and, after vapor is transported through the pores, condensation takes place at the cold interface. In this way a water flux occurs through the membrane in the direction from warm to cold. Obviously, for membrane distillation to proceed, it is essential that liquid water is excluded from the pores. In this sense, the role of the membranes is somewhat peculiar, since it acts as a physical support for the liquid-vapor interfaces. So for that the membrane characteristics should be-The membrane must be porous, the membrane must be not wet table by the liquids transported, only vapor will be transported across membrane matrix, there is not capillary condensation inside the pores of membrane , the vapor-liquid equilibrium must not be altered by the membrane,

at least one side of the membrane must be in direct contact with the liquids to be processed the driving force of this membrane operation is a partial pressure gradient in the vapor phase for each component.

Prof. Shakhashiri, [19] had researched on “Ethanol”. Ethanol is a clear, colorless liquid having agreeable odor. The chemical name of ethanol is CH_3CH_2OH. It contains a hydroxyl group (–OH), bonded to a carbon atom. Ethanol melts at –114.1°C, boils at 78.5°C, and has a density of 0.789 g/ml at 20°C. In dilute aqueous solution, it has a sweet flavor, but in more concentrated solutions it has a burning taste. Ethanol has been made by the fermentation of sugars. The raw material for ethanol is sugar. Zymase, an enzyme from yeast, changes the simple sugars into ethanol and carbon dioxide. Ethanol is used as fuel in automobile and as alcoholic beverage. It is useful as a solvent for many substances and in making perfumes, paints, lacquer, and explosives. Ethanol found in human body where water contain is more e.g. Brain and blood. Ethanol affects directly on the nervous system.

In Membrane Filtration [20], membrane is the thin layer of semi-permeable material which separates substances when a force is applied across the membrane. There are some filtration methods available like microfiltration, ultrafiltration, Nano filtration, reverse osmosis. Membrane filters are usually manufactured as flat sheet stock or as hollow fibers and then formed into one of several different types of membrane modules. There are some modules available like Hollow-Fiber Modules, spiral wound modules. When the feed material introduce on membrane then that material first get deposited on the surface of membrane and the concentrated molecules get suspension on flow and the get removed out. For cleaning of the membrane there are two methods available such as backwashing and cleaning chemically. Finally the most important part about membrane is it should be provide a barrier between the feed water and the permanent or product water.

Membrane Filter Technique [21], The Membrane Filter (MF) technique was introduced in the late 1950s as an alternative to the Most Probable Number (MPN) procedure for microbiological analysis of water samples. The MF separates colonies of bacteria whereas the MPN only indicates the presence and absence of organisms. The MF Technique was accepted by the U.S. EPA for microbiological testing of potable water in the 11th edition of Standard Methods for the Examination of Water and Wastewater. In the 1978 publication, Microbiological Methods for Monitoring the Environment, the U.S. EPA stated that the MF Technique is preferred for water testing because it permits analysis of larger samples in less time. Municipal water treatment plants monitor drinking, waste, and surface water for the presence of coliform bacteria by the MF Technique, the MF Technique is also used for microbial monitoring in the pharmaceutical, cosmetics, electronics, and food and beverage industries. The MF Technique is an effective, accepted technique for testing fluid samples for microbiological contamination. It involves less preparation than many traditional methods, and is one of a few methods that will allow the isolation and enumeration of microorganisms.

Samir Jain, [22] writes on “Ethanol-Water Phase Separation White Paper”. The use of ethanol as a fuel in the United States has significantly increased over the past decade. Today, greater than 80% of all retail gas stations in the US blend gasoline with up to 10% ethanol (E10). Ethanol is a renewable fuel, and has been highlighted by the national Renewable Fuels Standard as a primary method of achieving the renewable fuels goal. Ethanol is also an octane booster, and E10 fuels rely on the ethanol content to achieve octane levels. Most station owners typically use one or more of the following methods to detect phase separation, each of which has limitations: 1. Automatic Tank Gauge / Monitor with water detection: The center of the tank contains a magnet obstructive probe, which is a component in an automatic tank gauge (ATG). This probe is wired to a console, which is typically mounted in the back office of a gas station. Querying the console allows the user to determine various parameters in the underground tank. In

particular, there are floats for fuel and water that determine the respective levels of each. The water float is typically tuned for a density that will certainly lift in water but not in other lighter fluids (such as gasoline or diesel). 2. Water-finding paste: A common method of detecting water in a tank is to apply a special water-finding paste to the end of a stick and dip the stick into the tank, a process known as “sticking” a tank. A change in the color of the paste (varies based on paste manufacturer) may indicate the presence of water in the tank. 3. Filters: Each gasoline dispenser usually has a disposable filter inside it that filters out unwanted particulates prior to the fuel reaching the nozzle and customer vehicle. Some of these filters will also filter out water, by quickly constricting once water is detected.

Proposed increases in the ethanol blend levels will further elevate a stations’ risk to phase separation. These risks include damage to the petroleum infrastructure, damage to customer vehicles and station brand equity, and the potential to be left with unsellable fuel.

P. Shao and *et. al.* [23**]** in their research on “Polymeric membrane pervaporation”, discuss that pervaporation is a membrane process for liquid separation. A polymeric or zeolite membrane usually serves the separating barrier for the process. Pervaporation membranes fall into two categories, the homogeneous membrane and the composite membrane. The composite membrane can offer a higher permeation flux than the homogeneous one due to the much thinner thickness of the homogeneous membrane supported on a porous substrate. The composite membrane is thus suitable for industrial use.

Pervaporation has played an important role in solvent dehydration, and this application can be further extended by integrating pervaporation with other viable liquid-separating technologies, and by finding right materials for dehydrating some caustic solvents (e.g. nitric acid).Removal of organic compounds from water is a very promising application for pervaporation, however, continued research need to be done to improve the

hydrodynamics of the pervaporation system to reduce the mass transport resistance in the diffusion layer so that the concentration polarization can be effectively suppressed.

Literature Gap:

It is worth to mention that the term "pervaporation", a combination of words "permeation" and "evaporation" coined by P.A. Kober as early as in 1917. Most of the other methods of separation of isotope solutions by membrane is studies by considerable number of researchers. But most of them had focused on chemically prepared membrane to be used in pervaporation process. One of company from Swiss made nonwovens membrane by using spun bound nonwovens manufacturing technique. Nobody had thrown a light on pervaporation process by using needle punched nonwovens. Hence this research will be carried out by focusing on the manufacturing a needle punched nonwovens to be used as membrane in pervaporation process.

3. Objectives of Research/ Proposed Hypothesis:

3.1 Objective:

1. To manufacture the needle punch nonwovens and analyze the properties of this fabric as membrane fabric.
2. To develop membrane fabric by coating the needle punch nonwovens.
3. To study the performance characteristics of coated needle punched nonwovens.

3.2 Proposed hypothesis:

Non availability of fabric manufacturers for pervaporation membranes in India. All membranes are being imported from countries like Germany, Switzerland or other countries with necessary membrane housing/ module. The technology used for same is

very costly and requires huge investment. The operational cost is also high in existing process. The nonwovens developed by the needle punched technique are suitable to be used as membrane.

4. Methodology To Be Adopted:

The Methodology/ Laboratory Work:

4.1 Raw Material

For experimentation raw material used will be the manmade fibers such as polyester staple fiber and low melt staple fibers polyester base. The material will be sourced from manmade fibres manufacturing industry.

Raw Material Specifications

Material	Denier	Staple Length
Polyester Staple Fiber	1.5 D	51mm
Low Melt Fiber	4 D	51mm

4.2 Availability of Research Facility

The required machineries set up for carrying out the experimental work is available at DKTE Society's Textile & Engineering Institute, Ichalkaranji and DKTE Society's Centre of Excellence in Nonwovens.

4.3 Design of the Experiment (Manufacturing of Needle Punch Nonwovens)

The proposed design of the experiment for manufacturing different types of needle punched nonwovens will be as given below.

Needle Punch Nonwovens fabric	100 GSM	130 GSM	160 GSM	165 GSM	180 GSM

Total 05 samples of needle punched nonwovens of different GSM will be produced as per mentioned in experimental design.

4.4 Testing Of Needle Punched Nonwovens:

Needle punched nonwovens samples will be tested for following tests and suitable statistical tool will be used to analyze the test results.

Essential properties:

1. Pore size
2. Air permeability

Desired properties:

1. Thickness
2. Bursting strength
3. Tensile strength
4. Tear strength

4.5 Coating of needle punched nonwovens:

Suitable sample from the needle punched nonwovens will be coated by PAN at different levels of coating.

Needle Punch Nonwovens	Coating Level 1	Coating Level 2	Coating Level 3	Coating Level 4	Coating Level 5

4.6 Testing Of Needle Punched Nonwovens:

Coated needle punched nonwovens samples will be tested for following tests and suitable statistical tool will be used to analyze the test results.

Essential Properties:

3. Pore size
4. Air permeability

Desired Properties:

5. Thickness
6. Bursting strength
7. Tensile strength
8. Tear strength

4.7 Membrane Manufacturing and its application:

Membrane will be manufactured and will be tested for its application of pervaporation process on lab model machine.

5 Importance of study/ Society application:

International status:

Fuel is a natural resource and going to on one day. The only solution is the alternate to the same. Petrol can be added with anhydrous ethanol and the consumption of petrol can be minimized. Most of the countries like U.S.A., GERMANY, JAPAN, and BRAZIL have already started making use of ethanol in petrol at high %.

National Status:

India imports 90% of its fuel consumption. If we could use anhydrous ethanol in petrol mixing at higher % then it could bring down the price of petrol in our country. Bus we don't have our own technology to dehydrate the ethanol. So if this technology is developed then India could save in the foreign currency.

Significance of the study:

Bio-ethanol is a form of quasi-renewable energy that can be produced from agricultural feedstock. It can be made from very common crops such as hemp, sugarcane, potato, cassava and corn. In India Sugar industries is based on Sugarcane and are the major producers of ethanol. Technically, ethanol is produced in following steps. Major production steps includes:

Microbial fermentation of the sugar → distillation → dehydration

The project focus is mainly concerned with the third step i.e. dehydration, which is an energy intensive process. Dehydration of ethanol is traditionally achieved by three different methods:

- Azeotrope distillation
- Extractive distillation
- Molecular sieve

All above processes are highly energy intensive and needs high amount of heat to vaporize the feed.

Pervaporation (PV) process can be new alternative for low-cost ethanol separation. New developed nonwovens based Membrane filter in this pervaporation process, the polymeric barrier will separate the water from ethanol. This system needs only 30% of heat energy as compared with above said processes. Pervaporation is fully developed technology in developed countries like USA, Germany and Japan. But in India, there is not a single manufacturer of Pervaporation membranes. This is because of lack of availability of technology. The Prices of imported pervaporation equipment is not also very high. We can develop an import substitute for such costly system.

6 **Proposed Research Work Plan / Formulation And Structure Of Study :**

Sr. No.	**Proposed work**	**Duration Months**
3	Procurement of raw materials	01
4	Testing of raw material	03
5	Manufacturing different types (GSM) of needle punched nonwovens	04
6	Testing of different types (GSM) of needle punched nonwovens	01
7	Statistical Analysis of the data collected	01
8	Coating of needle punched nonwovens with different levels of coating	05
9	Testing of different types coated needle punched nonwovens	02
10	Statistical Analysis of the data collected	01
11	Application of coated nonwovens for pervaporation process	05
12	Collection and statistical analysis of data for performance of coated nonwovens	02
13	Results and discussion	05
14	Conclusion	01
15	Thesis write up	05
	TOTAL	36

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Signature **Signature**

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